Performance of 4-Dimensional Cellular Automaton Track Finder in CBM

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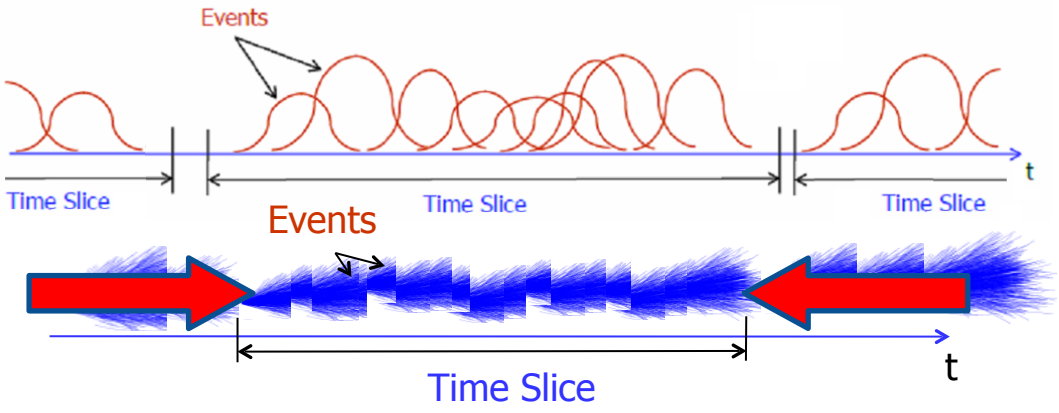
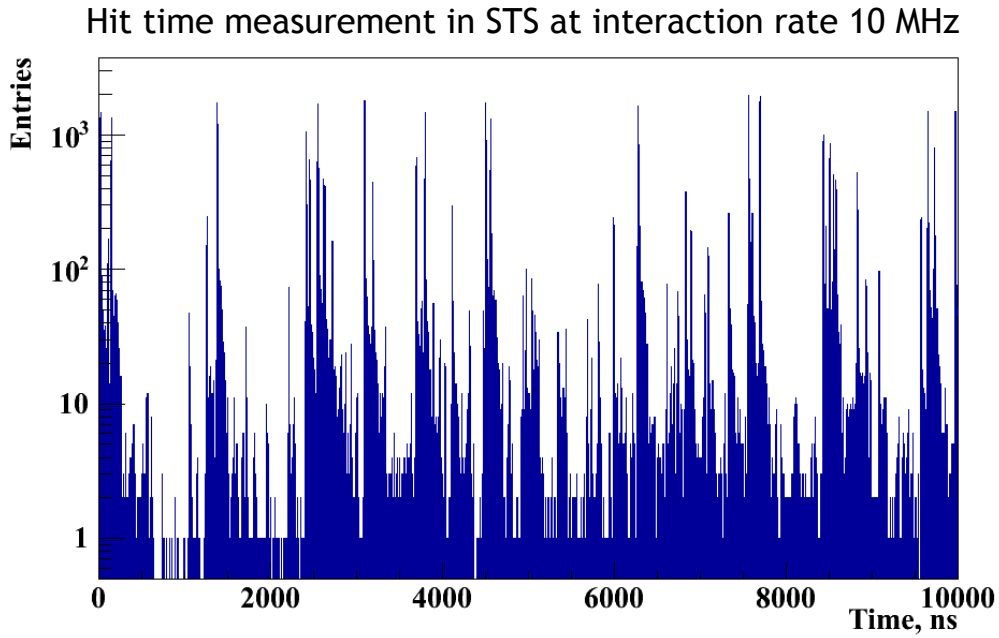
Reconstruction challenge in CBM





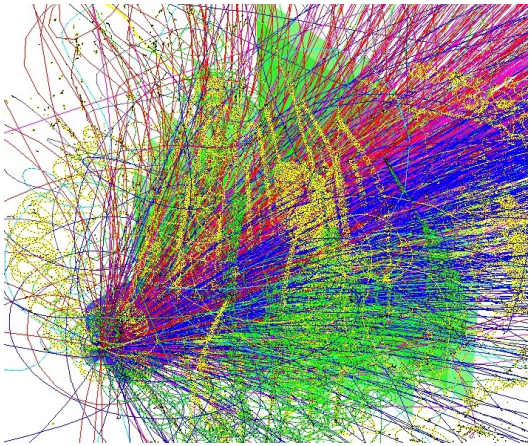
- Interaction rate up to 10 MHz
- free-streaming data
- self-triggered front-end electronics
- no hardware trigger

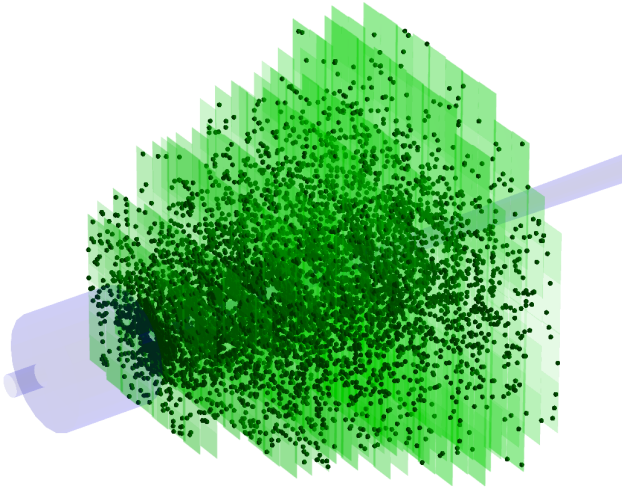
- Time-slice reconstruction rather than event-by-event
- Time-based tracking: 4D (x, y, z, t)

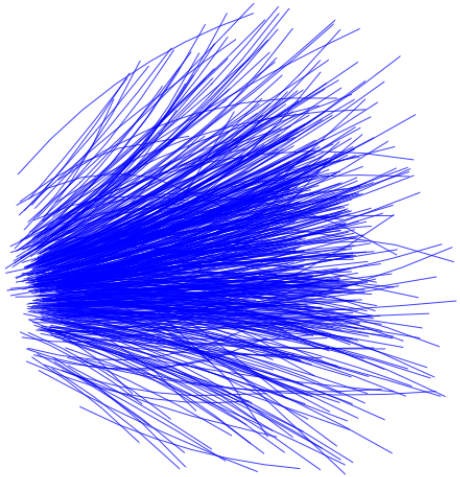
Events overlap on hit level

Correct procedure of event building from time-slices is crucial for right physics interpretation

Reconstruction challenge in CBM





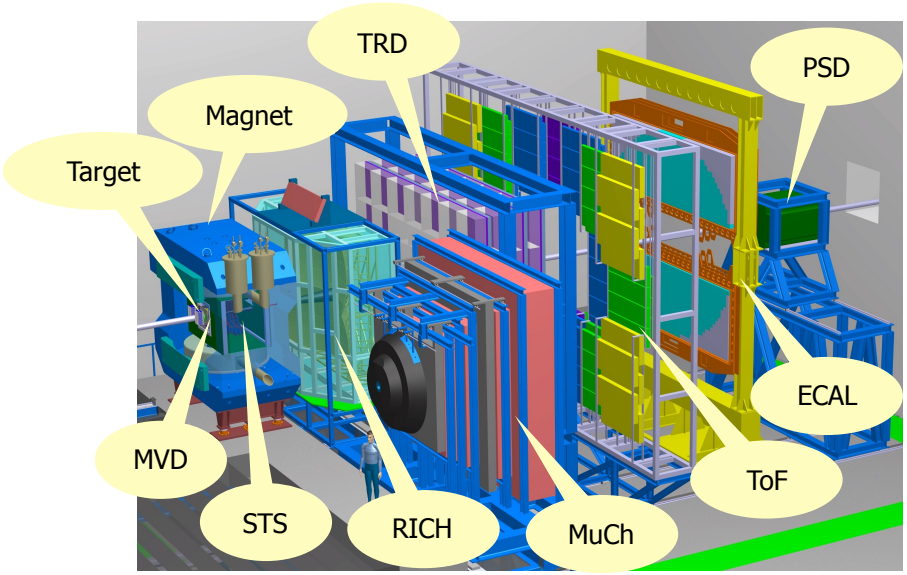


- Future fixed-target heavy-ion experiment
- 10^7 Au+Au collisions/sec
- ~ 1000 charged particles/collision
- Non-homogeneous magnetic field
- Double-sided strip detectors (85% fake space-points)

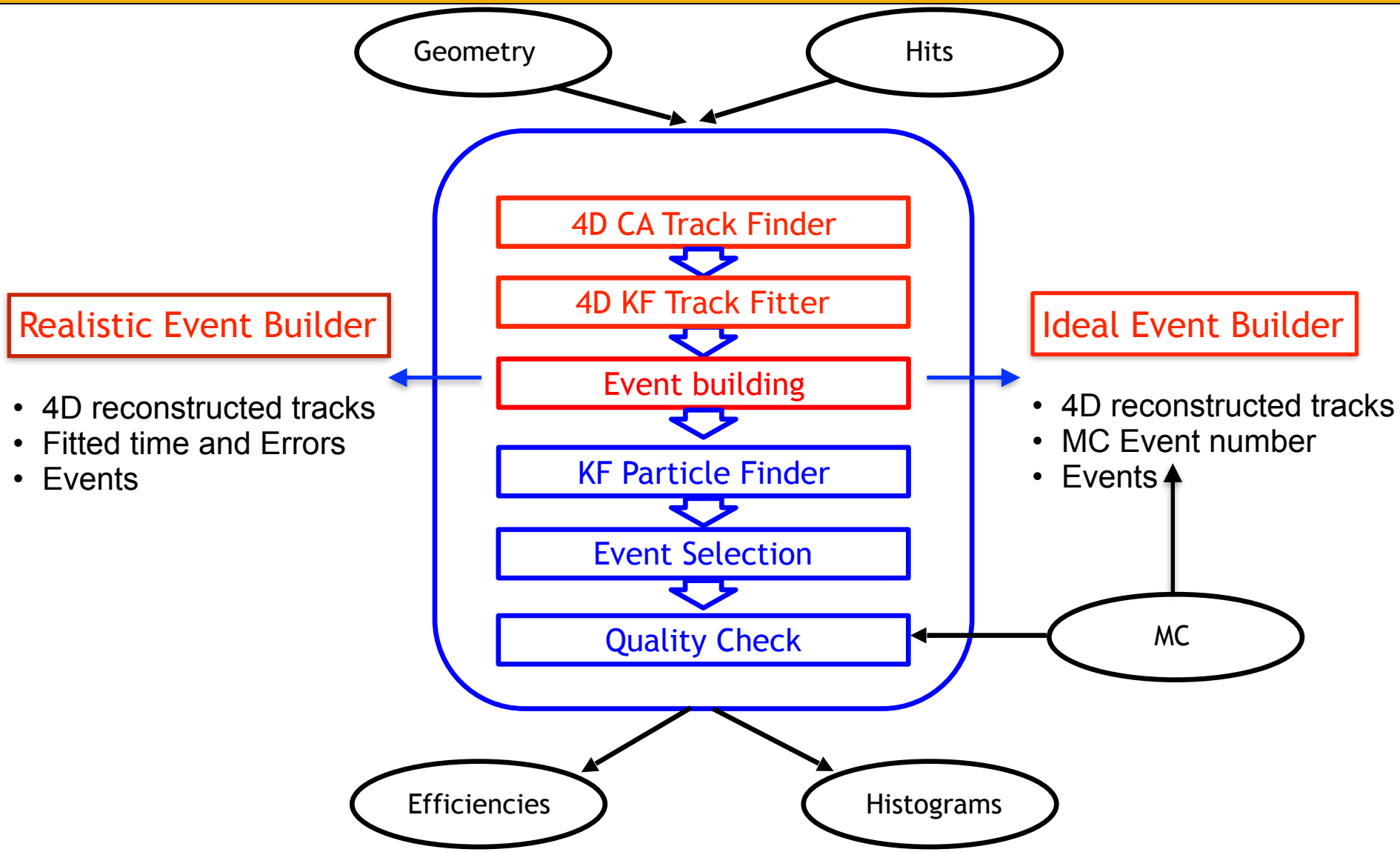
Full event reconstruction will be done
on-line at the First-Level Event Selection (FLES) and
off-line using the same FLES reconstruction package.

Cellular Automaton (CA) Track Finder
Kalman Filter (KF) Track Fitter
KF short-lived Particle Finder

All reconstruction algorithms are vectorized and parallelized.

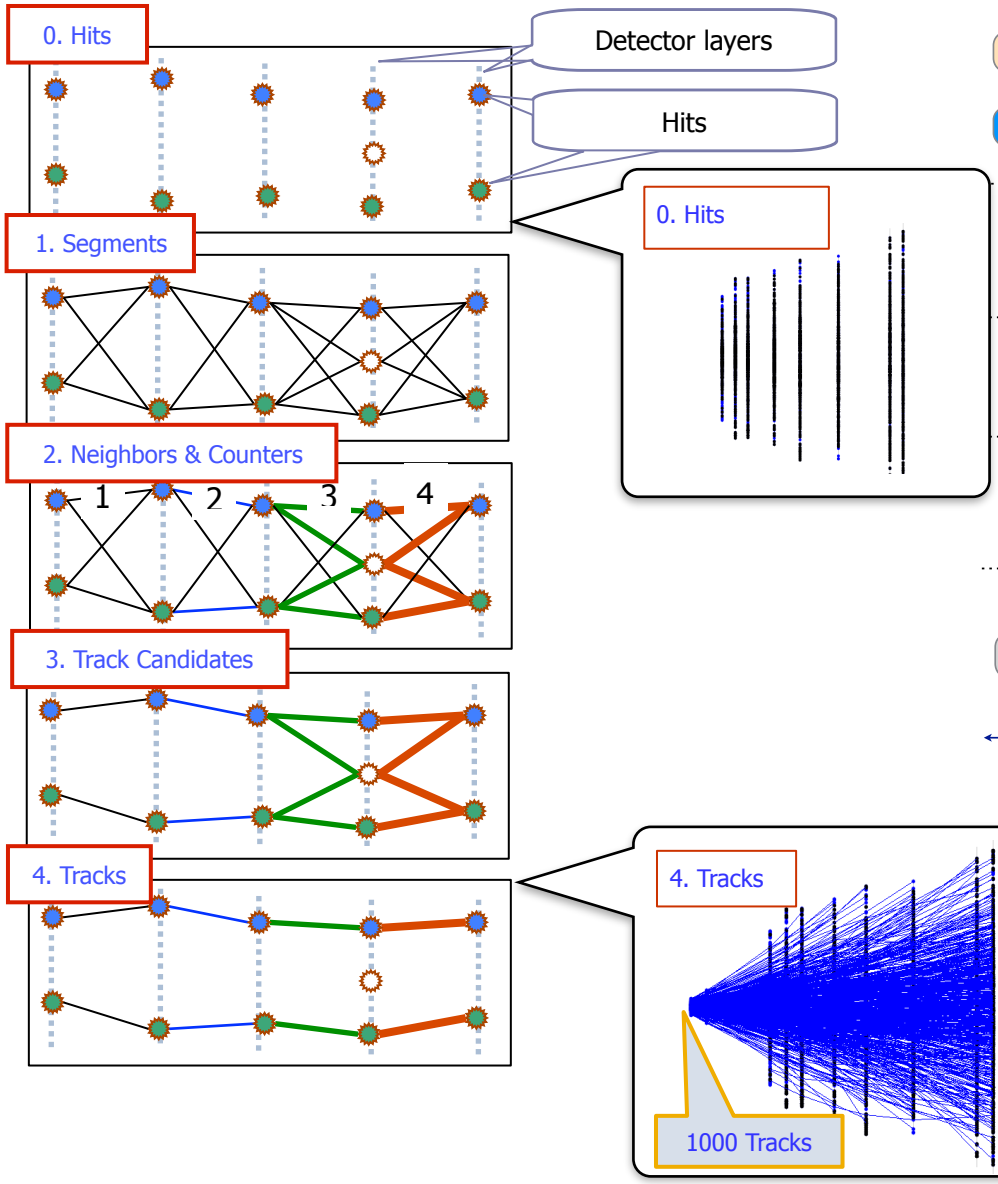


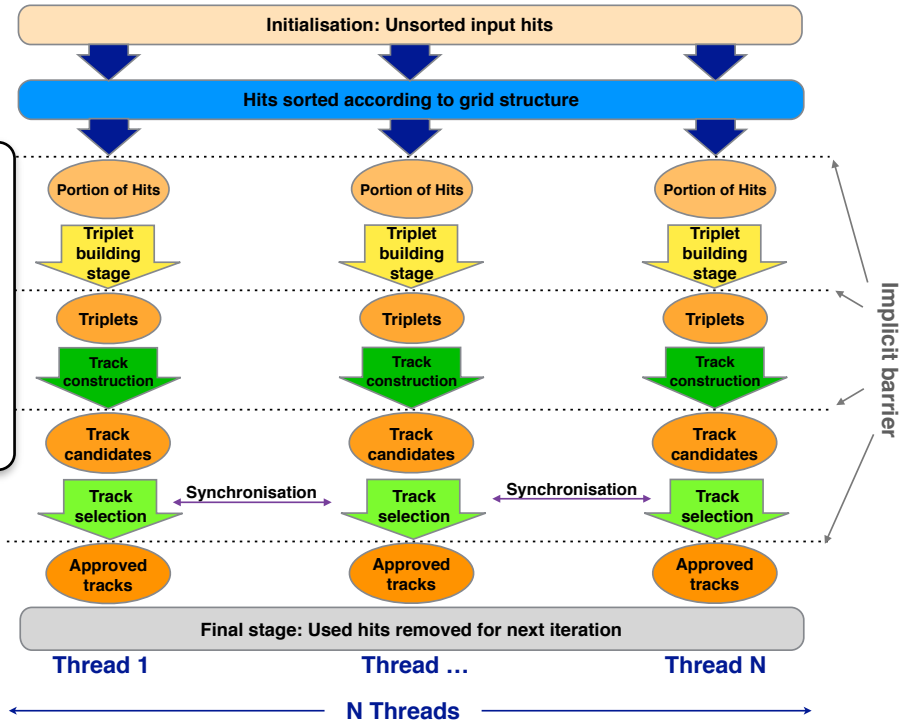
4D Reconstruction Chain



Event building as a part of the CBM reconstruction chain

Cellular Automaton Based Track Finder





Cellular Automaton:
- local w.r.t. data
- intrinsically parallel
- simple
- very fast

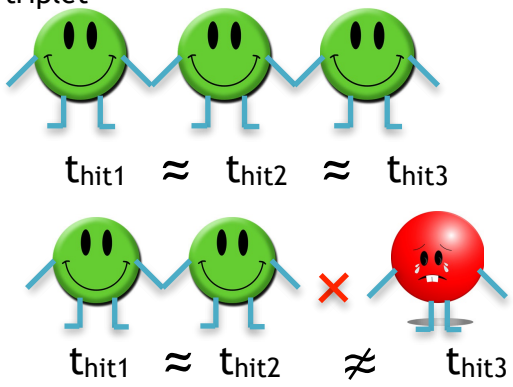
Perfect for many-core CPU/GPU !

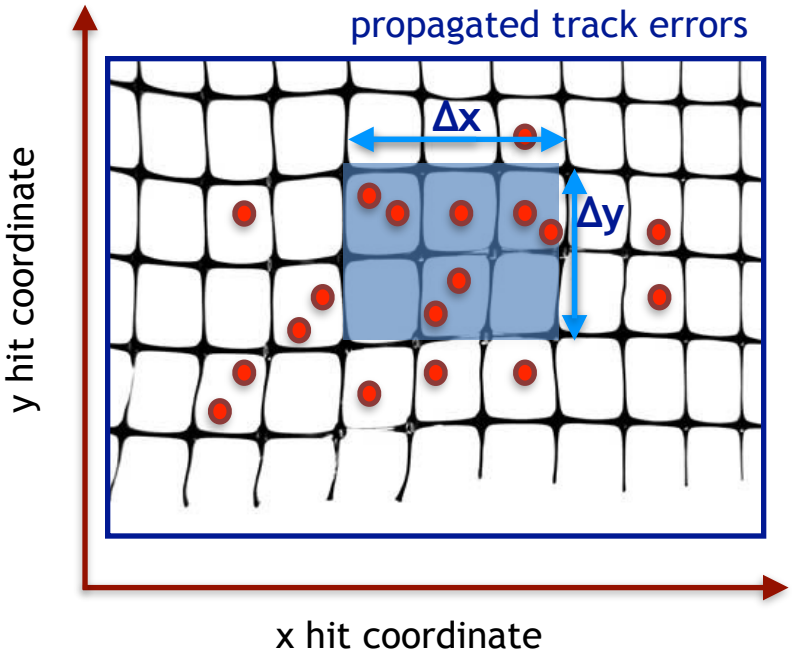
Time-based CA Track Finder

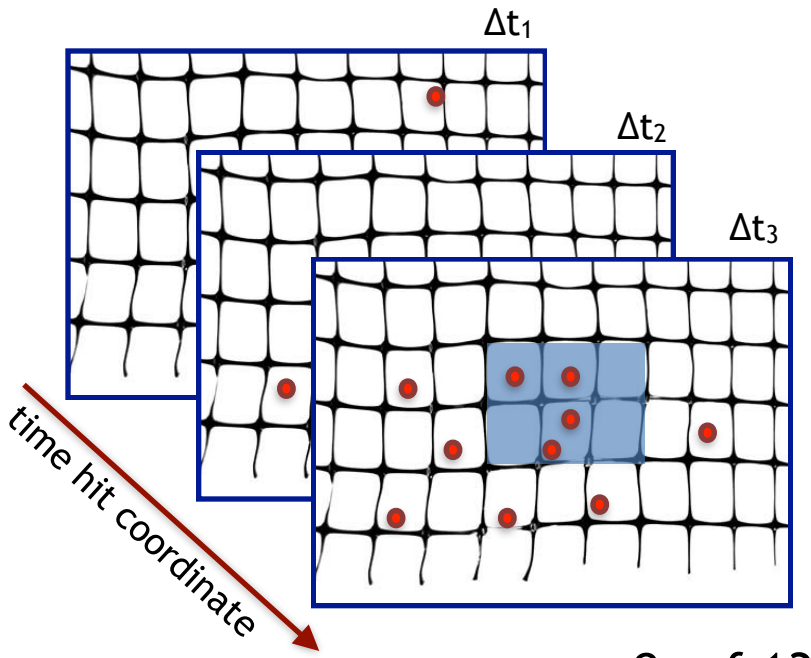
How to use time information in tracking?

- Triplets are build from the hits with the same time measurement within 3σ of detector precision
- Fast access to the hits is provided by time-based structure: hits are sorted by time and space coordinates and stored into the time-based grid
- Due to parallel concept memory is allocated before run and the whole time slice data is stored - constrain on the time slice size (100 mbias)

Hits time measurement have to be the same within detector precision to build a triplet







Variable time step of grid: 4D tracking in a 3D-style approach

4D Track Finder in CBMROOT

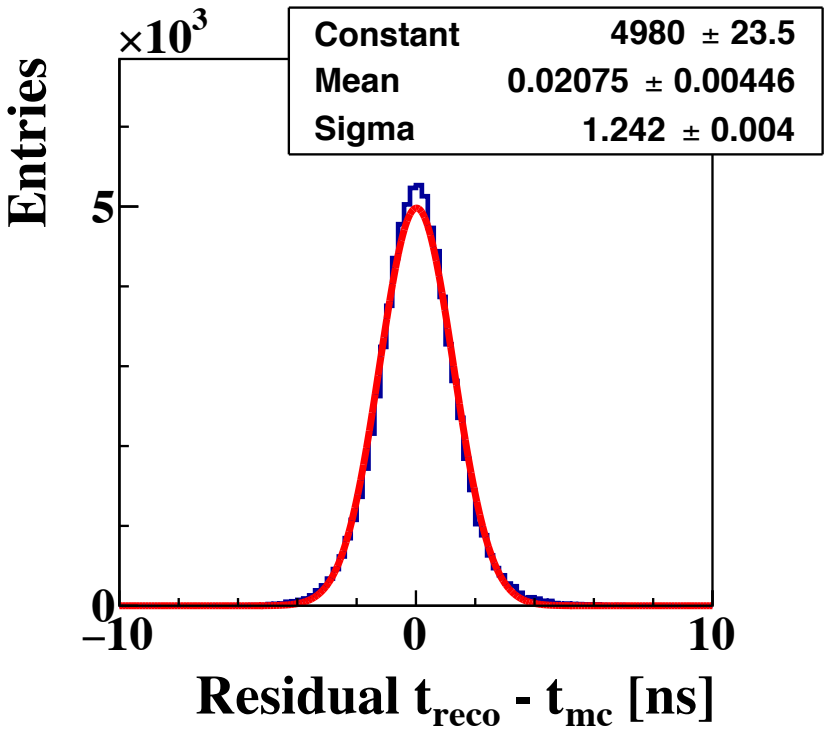
100 AuAu 10 AGeV mbias events

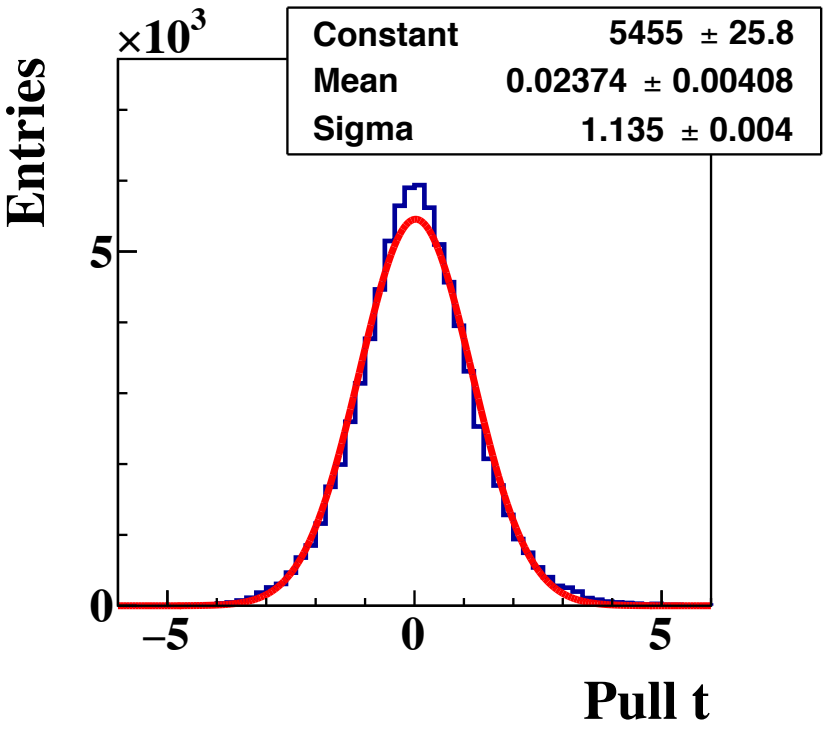
Efficiency, %	3D	0.1 MHz	1MHz	10 MHz
All tracks	92.5 %	93.8 %	93.5 %	91.7 %
Primary high-p	98.3 %	98.1 %	97.9 %	96.2 %
Primary low-p	93.9 %	95.4 %	95.5 %	94.3 %
Secondary high-p	90.8 %	94.6 %	93.5 %	90.2 %
Secondary low-p	62.2 %	68.5 %	67.6 %	64.3 %
Clone level	0.6 %	0.6 %	0.6 %	0.6 %
Ghost level	1.8 %	0.6 %	0.6 %	0.6 %
True hits per track	92%	93 %	93 %	93%
Hits per MC track	7.0	7.0	6.97	6.70

Timeslices from CBMROOT
Timebased digitisation, cluster and hit finder

4D Track Fit

$(x, y, t_x, t_y, q/p) \rightarrow (x, y, t_x, t_y, q/p, t)$

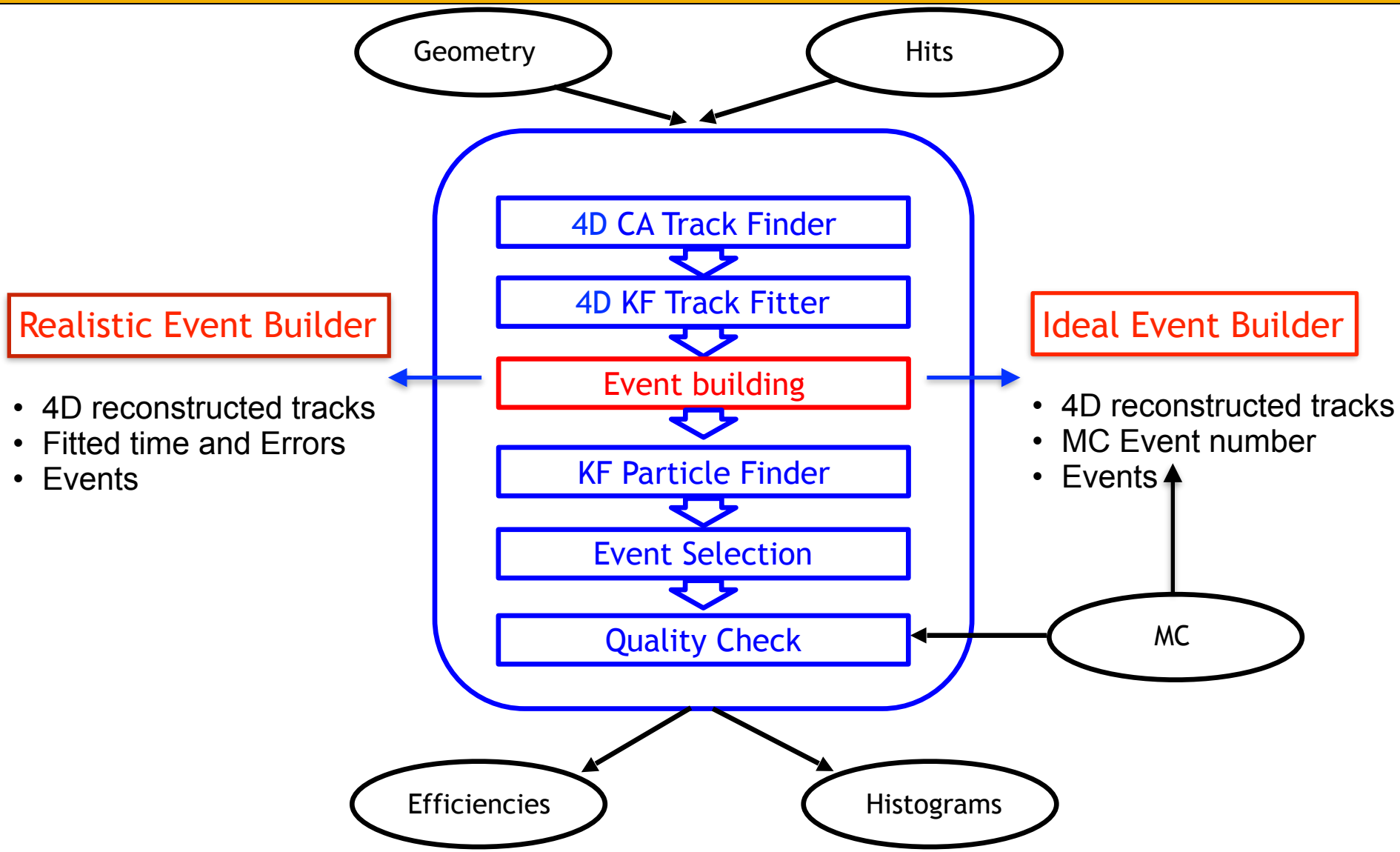




Time is added to the track fit:

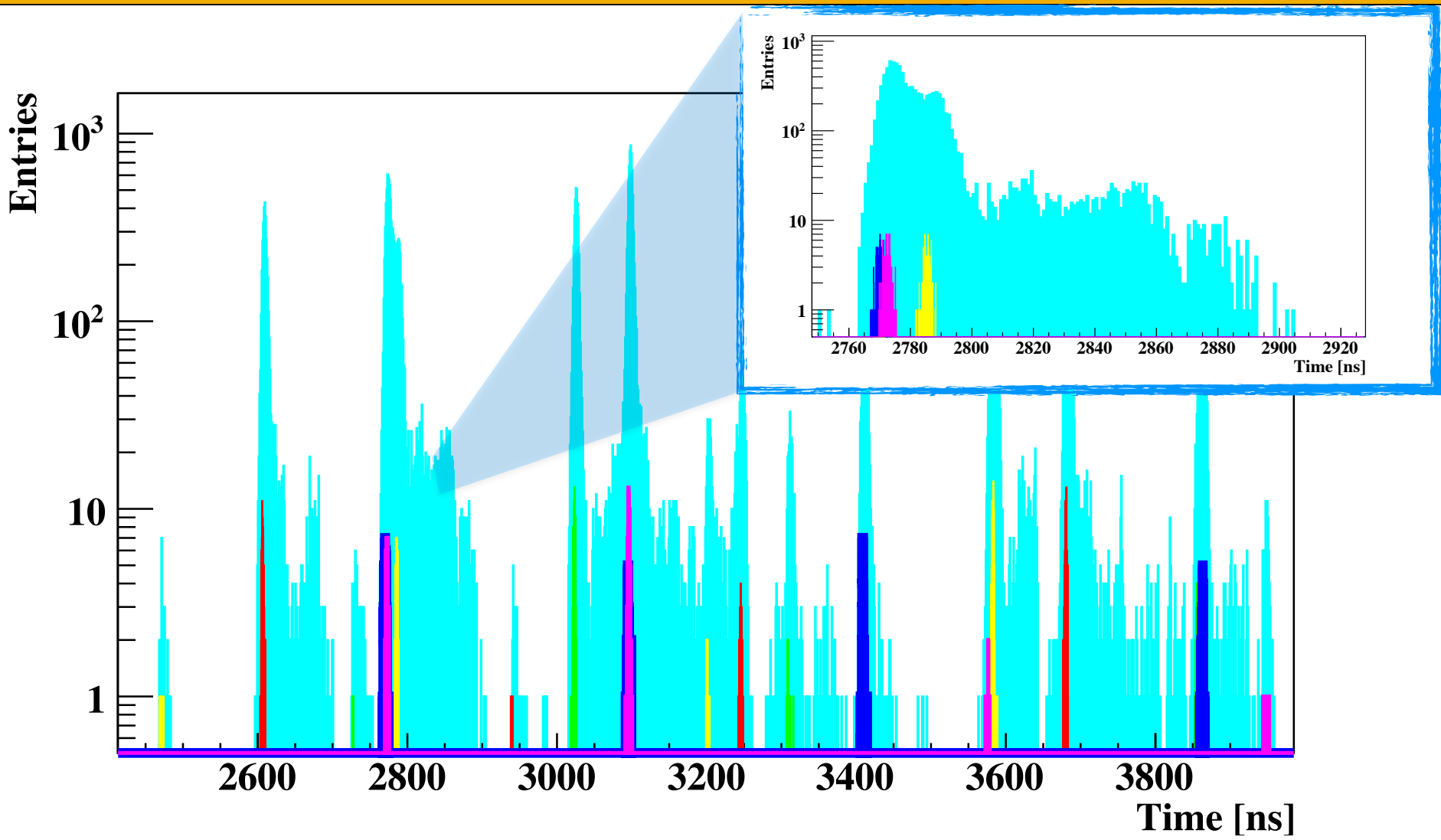
- The vector of parameters and its covariance matrix are extended.
- Propagation and Kalman filter are extended.
- Errors for all hits assumed constant.
- Fit shows correct results: high resolution and pulls close to 1.

4D Reconstruction Chain



Event building as a part of the CBM reconstruction chain

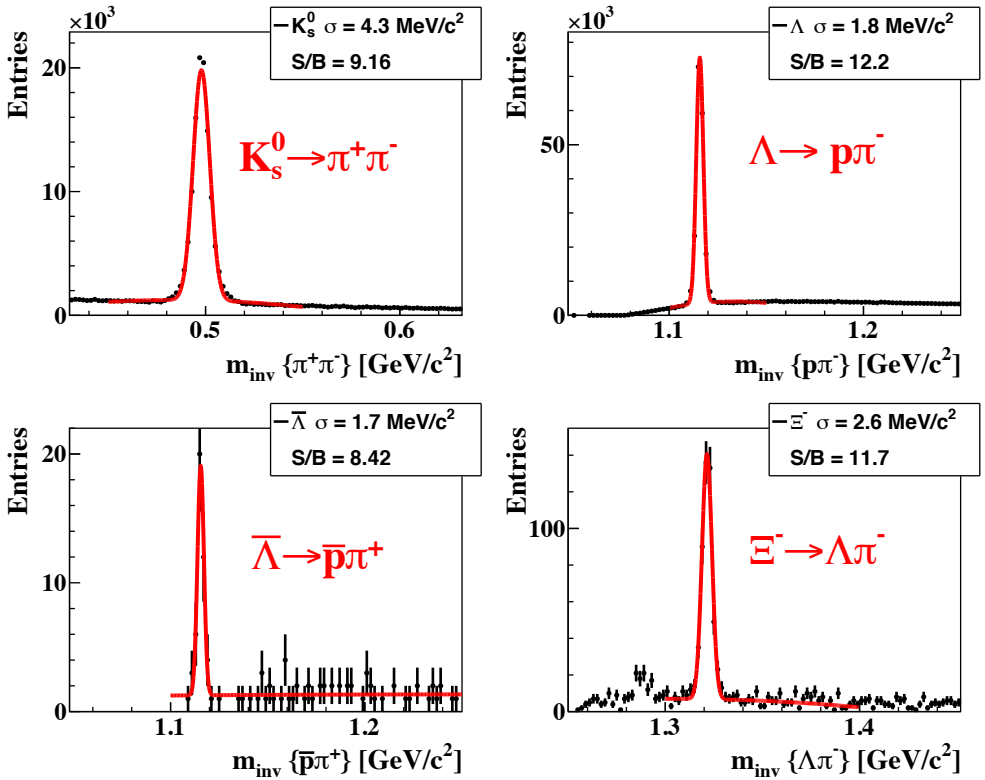
Ideal Event Builder



Fraction of events overlap on track level within STS time resolution and require topology analysis

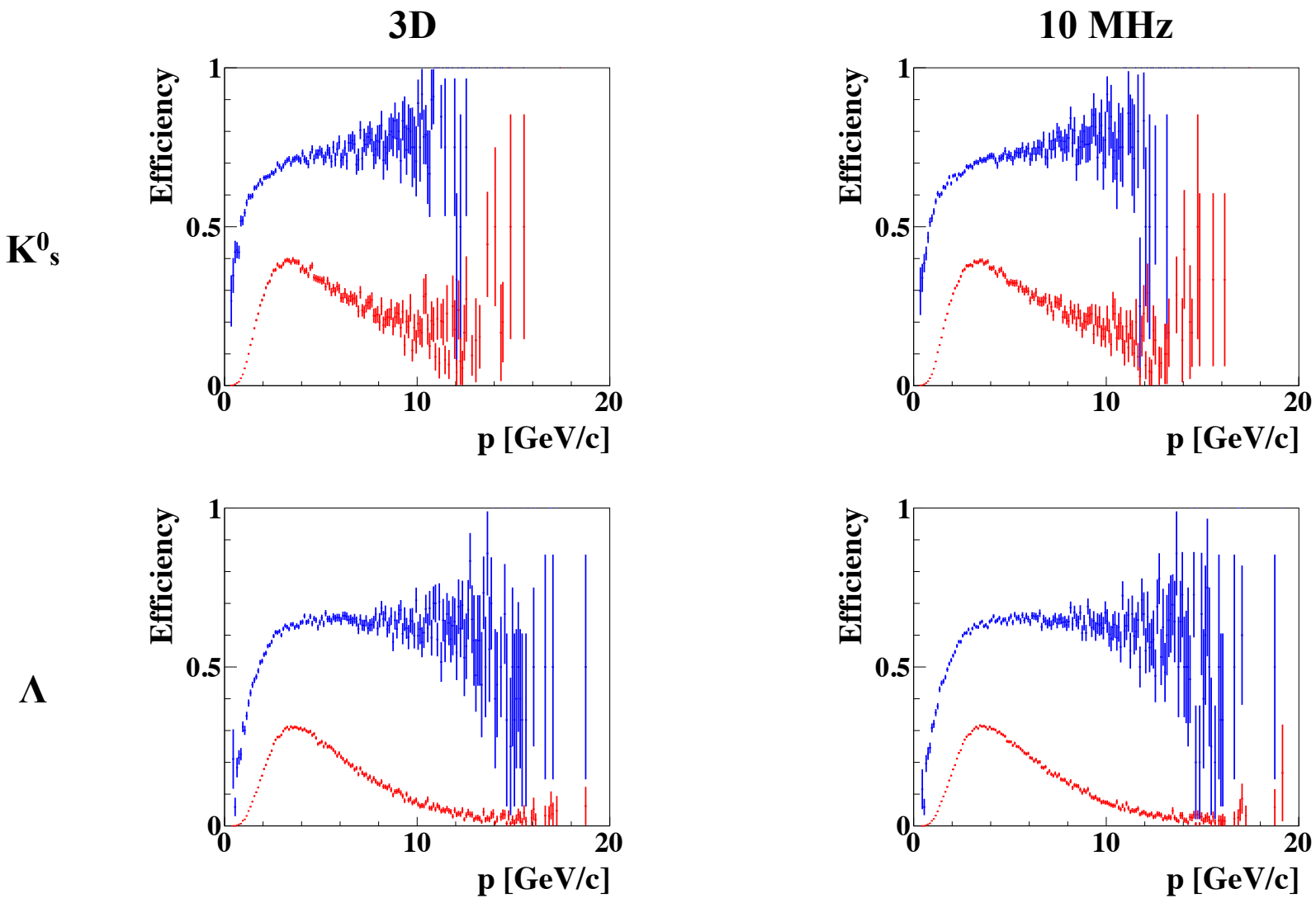
KF Particle Finder with time-slices

10 MHz, AuAu, 10 AGeV, 300k mbias UrQMD events, ideal PID, **realistic EB**



- 4D reconstruction chain from hit production to physics analysis level is established.
- Monte Carlo PID is used for track identification.
- Extreme case of 10 MHz interaction rate will require further include of the information from fast detectors (ToF) and multi primary vertex analysis.

Efficiency Momentum Distribution



Conclusions and Outlook

Conclusions:

- First version of time-based reconstruction chain is established
- Time-based 4D track finder, track fitter have been developed.
- 4D reconstruction is efficient and scalable.
- Realistic Event Builder algorithm is under development
- First version of time-based physics analysis is implemented.

Outlook:

- Include ToF information
- Multi primary vertex analysis
- Include realistic PID